books

Using physics to find oil, minerals, military targets

Geophysics in the Affairs of Man

C. C. Bates, T. F. Gaskell, R. B. Rice
492 pp. Pergamon, New York, 1982. $60.00 cloth, $25.00 paper

Reviewed by Ralph D. Bennett

The subtitle of this book is *A Personalized History of Exploration Geophysics and its Allied Sciences, Seismology and Oceanography*. Indeed, in addition to providing an encyclopedia, and highly readable, coverage of earth physics, the book cites key accomplishments contributed by many of the more than two thousand men and women who have been active in the field within the United Kingdom, Canada and the United States. This story acquaints the reader with how physics has been brought to bear on the search for oil, natural gas and metallic minerals. It also deals with searches for military targets—heavy artillery, submarines, undersea mines and lost hydrogen bombs. It describes the creation of the technology required to verify adherance to underground nuclear test ban treaties.

After touching lightly on accomplishments before the 20th century, the narrative reviews in increasing detail progress from World War I to the present. W. Lawrence Bragg headed the British effort to locate enemy artillery by geophysical methods. After the war, some of his collaborators in the US, led by William P. Haseman, mapped areas of Oklahoma by seismic methods. Although their first effort failed financially, by 1926 refraction seismograph crews were finding new oil fields in coastal Louisiana and Texas at remarkably low costs.

These successes led to the founding of the new petroleum geophysics industry, which in 1980 spent over three billion dollars in the continuing worldwide search for new energy deposits. The primary sensors were seismic, gravitational, magnetic and electrical. The measurements are supplemented by very sophisticated data processing that makes exploration geophysics one of the largest users of computer time.

In its longest chapter the book, turning to geophysics as a business, describes the varying degrees of success geophysical firms have had. Of particular interest is the multinational conglomerate Texas Instruments.

The closing chapter, "Geophysics As They Saw It," records the reflections of two score participants in the business. Among them are writings of Sir Harold Jeffries, Maurice Ewing, Frank Press and J. Tuzo Wilson. The presence of many pictures taken over the years enhances the personal character of the book. Unfortunately they are too small to make identification of individuals easy in group pictures.

This collection of facts, figures and personal adventures could have been assembled only by long-time, vigorous and widely acquainted participants in geophysics. Such are the authors. Thomas Gaskell is vice president of the Royal Astronomical Society, which publishes its own earth science journal. Charles Bates and Robert Rice have served as vice president and president, respectively, of the Society of Exploration Geophysics.

All in all, this book provides a lucid, enjoyable overview of governmental, academic and industrial geophysics and their intricate interactions.

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Ralph D. Bennett was Technical Director of the US Naval Ordnance Lab and headed the Advisory Board of the US Naval Oceanographic Office.

Bank of Geotech helicorders, which provide real-time monitoring of worldwide earthquakes by the global seismology branch, US Geological Survey, at Golden, Colorado (photograph courtesy US Geological Survey).

Modern Crystallography. Vol. 1. Symmetry of Crystals, Methods of Structural Crystallography

B. K. Vainshtein
399 pp. Springer, New York, 1981. $47.50

Vol. 2. Structure of Crystals

B. K. Vainshtein, V. M. Fridkin, V. L. Indenbom
433 pp. Springer, New York, 1982. $49.00

By the early 1950s x-ray crystallography had become firmly entrenched as a scientific discipline in its own right and as one of the more important research tools of chemists, physicists, biologists, materials scientists and others. Industry and technology used x-ray methods

routinely in investigations of polycrystalline materials for the identification of crystalline phases in "unknowns," as well as for the determination of residual stresses in metals, particle sizes in powdered materials, and the textures of fibers and synthetic polymers.

X-ray crystallography had come of age but had yet to find an appropriate place within the academic hierarchy. Some schools of mineralogy continued to place emphasis on the study of "classical crystallography," that is, on the study of macroscopic crystal structure, with courses in x-ray diffraction reserved for more advanced students. Most universities, however, offered courses in crystallography in several departments, depending on local circumstances. These generally exposed students to a bare minimum of crystallography, to just enough to enable them to go on to what appeared to be the more exciting field of x-ray diffraction. To a large extent, that situation prevails to this day.

In the four volumes of *Modern Crystallography*, Boris K. Vainshtein, the director of the Institute of Crystallography of the Academy of Sciences of the USSR, attempts, with some help from a number of colleagues, to bring together the many branches of crystallography, to take account of their complex relationships with other disciplines, and to present crystallography as a coherent and unified science. Volumes 3 and 4 of the series have not yet appeared in print. They will deal with the *Formation of Crystals* and the *Physical Properties of Crystals*.

Almost all of Volume 1, *Symmetry of Crystals, Methods of Structural Crystallography*, and much of Volume 2, *Structure of Crystals*, were written by Vainshtein. Few crystallographers are better equipped to undertake so formidable a task. In many respects, Vainshtein is the "Renaissance man" of Soviet crystallography. He is a leader in diffraction theory, x-ray and electron diffraction, electron microscopy, polymer science and molecular biology. Nevertheless, his efforts and those of his colleagues have not been wholly successful.

Almost half of the first volume is devoted to a detailed and somewhat formal presentation of the theory of symmetry. The illustrations are plentiful, carefully drawn, and often very attractive, especially those dealing with color symmetry. I doubt, however, whether so much space for symmetry is justified when only seven pages are devoted to polycrystalline materials and only 25 go to the determination of crystal structures. The favored treatment accorded symmetry appears to reflect the author's personal tastes more than the needs and interests of the probable readers.

The need for concise treatment of wide ranges of subject matter imposes severe constraints on the authors. Brevity is sometimes achieved at the cost of adequacy of treatment. In some cases, however, and particularly in the sections written by Vainshtein, the treatment is clear and concise, with evidence throughout of his profound and encyclopaedic knowledge of the subjects discussed. The author is at his best in Volume 2, where, in the first two chapters, he presents elegant and comprehensive discussions of the principles of structure formation and of the "Principal Types of Crystal Structures." The latter is almost unique in the crystallographic literature in that it presents, in one chapter, detailed and illuminating discussions of subjects as diverse as intermetallic structures, structure of high polymers and structures of substances of biological origin, topics that are usually treated superficially or not at all in crystallographic texts. In all cases, the material is presented from the point of view of the structural crystallographer.

The material at the back of the book is not adequately assembled. The bibliographies are extensive, but give no indication of critical selection. They appear to be designed for display rather than for use. Smaller, carefully selected listings would be much more useful. The subject indexes to the two volumes are far too sketchy; their cross-listings are sporadic and unsystematic. The usefulness of the subject indexes would, nevertheless, be significantly increased by the addition of a "name" index.

Modern Crystallography, we are told, was designed for use by research workers involved in crystallography and related areas, and for undergraduate and graduate students of the solid state. Unfortunately, the level of treatment is often too advanced for undergraduates and insufficiently detailed for graduate students involved in crystallographic research. It is, however, well suited to serve as an authoritative reference manual for anyone working in, or simply interested in, the solid-state sciences.

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Excitons: Their Properties and Uses

D. C. Reynolds, T. C. Collins
291 pp. Academic, New York, 1981. $36.00

This book aims to present the basic properties of excitons to graduate students of the solid state and to scientists in materials technology. In fact, it treats only the Wannier exciton (a positronium-like bound state of an electron and a hole, describable in the effective mass approximation). Most of the book is devoted to the energy levels and Zeeman effect of free and bound excitons in semiconductors. In particular, the authors present in great detail their own theoretical and experimental results and those of their colleagues. They devote considerable space to many-body theory, to the electron–hole liquid, and to donor–acceptor pairs, none of which has much to do with excitons. On the other hand, there is very little on exciton dynamics, even on such fundamental properties as mobility and nonradiative decay. Outside the specialized area on which they concentrate, the treatment is sketchy and often out of date. For example, the chapter on the excitonic polariton (an exciton and photon so strongly coupled together that they lose their separate identities) ignores the work on "spatial" dispersion and light scattering that transformed this subfield in the mid 1970s. Even where they have devoted their greatest efforts they hardly discuss the physics behind the theoretical formulae or what the data signify. However, the book ends with a useful compilation of the materials properties of silicon, germanium and many binary semiconductors.

The exposition is awkward and obscure. For example, the vital factor $1/\epsilon$ (ϵ is the dielectric constant) is omitted from the exciton Hamiltonian until it suddenly appears, without explanation, in the complicated Hamiltonian for an anisotropic exciton in a magnetic field. The authors' obscurity misleads as well as puzzles; for instance, in one section they seem to imply (incorrectly) that the electron–hole liquid is stable even in the Hartree–Fock approximation. When a statement is unambiguous, it is often incorrect. For example, the electric dipole operator transforms in T_d as Γ_5, not Γ_4 as they state. The book has not been edited carefully. Misprints are so abundant that one loses all faith in the formulae. The notation is not consistent, even from page to page. Many symbols are defined, if at all, long after their first appearance (there is no table of symbols). Figure and table captions are often incomprehensible. Many names are misspelled.

In 1965 David Dexter and Robert Knox published an excellent little book *Excitons*, which is now, regrettably, out of print. Since then the subject has grown so vast that books on it tend to be multi-authored collections of specialized review articles. We badly need a new synthesis, a concise and unified book accessible to nonspecialists that, in John Ziman's phrase, will "turn